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CHROMITE IN PENNSYLVANIA

By

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Former large output. For several decades in the nineteenth century Pennsylvania and Maryland furnished almost the total world's supply of chromite. The deposits in these states were of enormous size, as can be realized from the production figures of 100,000 tons for the Reed* mine (Harford County, Maryland) and 120,000 tons for the Wood** mine, Lancaster County, Pennsylvania.

In comparison, the largest body of chromite recently mined in the United States,*** and a truly large deposit for chromite (at Castle Crags mine; on Little Castle Creek, Shasta County, California) contained only 12,000-18,000 tons. It is justifiable to assume, from the information at hand, that deposits of chromite as large as those formerly worked can be discovered in Pennsylvania by explorations based on careful geologic and magnetic surveys.

Geologic relation: In Pennsylvania the chromite deposits occur in rocks which, because of their composition and location, are called the "State Line serpentines." The soil of the region in which these rocks occur is unproductive; hence the name "The Barrens" has been applied to the land underlain by serpentine.

Serpentine areas extend in a westerly direction through Delaware, Chester, and Lancaster Counties. The outcrops then trend southwest, cross the State Line, and continue to a point in Maryland northwest of Baltimore. Chromite deposits, both massive and sands, have been found at several places in this area.

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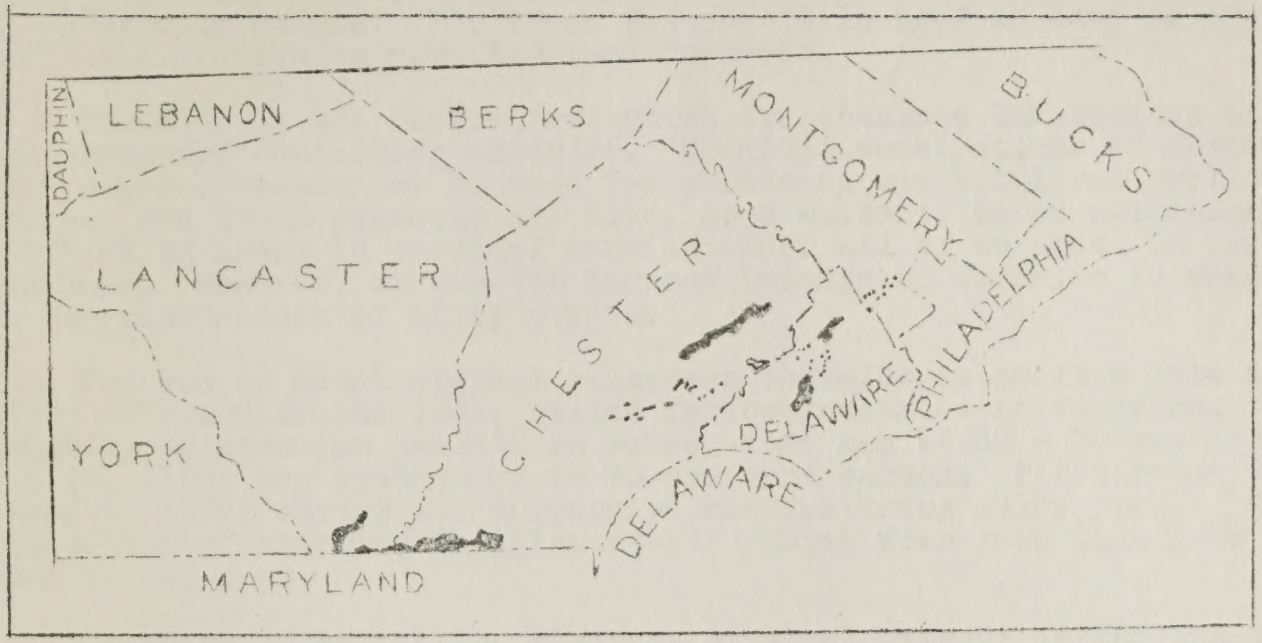
* Mineral Resources of the United States, 1883-1884; p. 568, 1885.
**Genth, F. A., Second Geol. Survey of Pennsylvania, Report B, p. 41, 1875.
*** Diller, J. S., Recent Studies of Domestic Chromite Deposits, Trans. A. I. M. E., Vol. LXIII, p. 111, 1920.

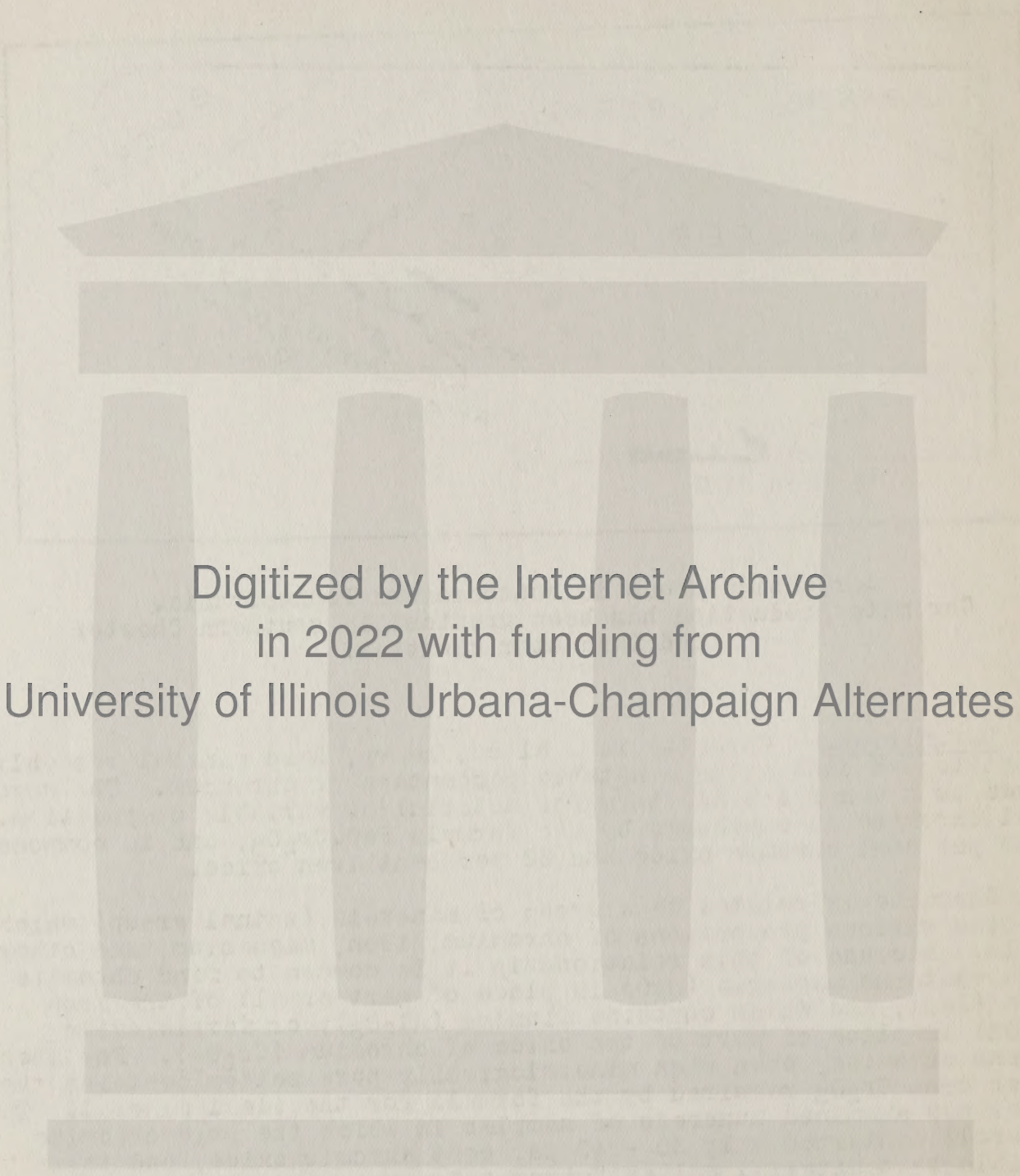


Serpentine areas in southeastern Pennsylvania.
Chromite production has been greatest in southern Chester and Lancaster counties.

Definition. Chromite is a black, heavy, hard mineral resembling magnetite and containing a notable percentage of chromium. The word is used as a general trade term for material of variable composition. Ideal chromite is expressed by the formula $FeO.Cr_2O_3$, and is composed of 68 per cent chromic oxide and 32 per cent iron oxide.

Chromite is related to a group of minerals (spinel group) which contains various proportions of chromium, iron, magnesium, and other metals. Because of this relationship it is common to find chromite which contains magnesia (MgO) in place of part or all of the iron oxide (FeO), and which contains alumina (Al_2O_3), or ferric oxide (Fe_2O_3) in place of part of the oxide of chromium (Cr_2O_3). For these reasons chromite, even when mineralogically pure seldom contains the 68 per cent Cr_2O_3 required by the formula for the ideal mineral. The writer has examined hundreds of samples in which the pure chromite (mineral) contained only 35 - 45 per cent chromic oxide, and it is possible that material called "chromite" may contain much less.

The importance of this substitution or replacement feature of the mineral is at least twofold: (1) chromite may be so strongly magnetic as to appear to be magnetite, thus being deceptive as to its true character, and (2) labor and money may be uselessly expended in trying to concentrate mechanically beyond the actual chromic oxide content of the mineral. The true solution of such difficulties is to



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be had only by very careful examination. Pennsylvania chromite, however, is of very high grade.

Uses. Chromite is difficult to melt, is chemically inert, and is physically strong. For these reasons it is used in lump or crushed condition for lining metallurgical furnaces.

Chromite is the source from which are obtained the various alloys and chemicals containing chromium. Chemical combinations of chromium with other elements may be used for producing beautiful red, yellow, orange, and green pigments and dyes; as a mordant; as an oxidizing or a bleaching agent in chemical manufactures; and as an agent in tanning leathers. However, by far the largest tonnage of chromium is consumed in the manufacture of alloy steels.

For use in metallurgical processes chromite is smelted into an alloy of chromium and iron, called ferrochromium or ferrochrome. The quantity of chromium present in ferrochrome may be 50 - 70 per cent, and the alloy may contain up to 10 per cent carbon. Ferrochrome is added to steel during the process of manufacturing alloy steel. The proportion of chromium in alloy steels ranges from less than 1 to more than 20 per cent.

Chromium increases the hardness of steel without increasing the brittleness. Alloy steels such as tungsten-steel, manganese-steel, nickel-steel, molybdenum-steel, etc., all contain chromium in addition to the tungsten, manganese, nickel, or molybdenum. This fact indicates chromium's very important position in alloy steel manufacture. Since the steel industries are manufacturing alloy steels in increasing proportions it is evident that the importance of chromite production as a "key" industry is increasing.

Proportionate consumption by industries. The following quotation* indicates the approximate ratios of the industrial demands for chromite:

"Early in 1918 the War Industries Board, after a canvass of the consumers, made an estimate of the quantities of chromite that would be required in 1918 by the different domestic industries. The total estimated requirement was 130,000 tons of 50 per cent ore, which, reduced to percentages by uses, amounted to the following figures: For ferrochrome 52 per cent, for chemicals 31 per cent, for refractories 17 per cent. These figures, however, are only approximate and would not apply to a normal year, but they show the order of magnitude of the requirements of the several industries."

Present production. About three-fourths of the present world production of chromite is obtained in Rhodesia (British South Africa) and New Caledonia (an island about 600 miles east from Australia.) Other localities from which more or less important quantities have been obtained are Canada, Greece, Baluchistan, Russia, Turkey (Smyrna), India (Mysore), and the United States (California and Oregon). There is no recorded production of chromite in Pennsylvania for many years.

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* Mineral Resources of the United States, 1920, pt. I, p. 22; 1921.

The following table shows the relations between domestic production and imports in the United States:

Domestic sales, imports, and apparent consumption of chromite in the United States, 1913 and 1917-1921.*

Year	Domestic sales			Imports		
	Long tons	Value	Average value	Long tons	Value	Average value
1913	255	$2,854	$11.19	65,180	$622,821	$9.56
1917	43,725	1,049,400	24.00	72,063	1,110,659	15.41
1918	82,430	3,955,567	47.99	100,142	2,892,825	28.89
1919	5,079	129,302	25.46	61,404	1,381,497	22.50
1920	2,502	44,857	17.93	150,275	1,921,824	12.79
1921	282	2,900	10.28	81,836	654,602	8.00

Apparent available supply

Year	Long tons	Value	Average value
1913	65,435	$625,675	$9.56
1917	115,788	2,160,059	18.66
1918	182,572	6,848,392	37.51
1919	66,483	1,510,799	22.72
1920	152,777	1,966,681	12.87
1921	82,118	657,502	8.01

* Mineral Resources of the United States, 1921, Part I, p. 16, 1922.

From the foregoing figures it is very apparent that the domestic markets will absorb a much greater domestic tonnage provided competition in price, quality, and condition can be met.

Occurrence in Pennsylvania. Deposits of chromite occur under such circumstances in Pennsylvania as to indicate that they were formed by crystallization from masses of molten rock. Furthermore, in such an event chromite is one of the first minerals to crystallize. Because of this fact it may be scattered in small grains through the rock which contains it, or it may occur in large masses. The former type is the disseminated or (locally) "bird's-eye" ore, and the latter is the "rock chrome" or "rock ore."

Weathering agencies (rain, wind, heat, and cold, etc.) disintegrate rocks and carry off the smaller particles. Chromite is very weather-resisting, and being "heavy" it forms natural concentrations or placers in positions down-stream from the deposits. Ore of this character is known as "sand chrome" or "sand ore."

The rock ore is an excellent grade of chromite in lump form. The "bird's-eye" ore, being disseminated, requires crushing and concentration to make it marketable. The "sand ore" is already disintegrated and roughly sized and concentrated by weathering agencies. Only rough washing is necessary to prepare it for market.

Analyses. Massive chromite in Pennsylvania frequently contains over 50 percent chromic oxide.* As mined, samples have contained as high as 56 per cent. Regular shipments from the Wood Mine, Lancaster County, contained 48 per cent.

The chromic oxide content of the "Bird's-eye" ore is variable. The lowest grade which can be mined will be determined by operating costs and market prices.

Stream chrome or sand ore contains about 45 per cent chromic oxide where ample opportunity has been given for concentration by running water.

The following analyses indicate the compositions of Pennsylvania chromites:

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* See reports Second Pennsylvania Geological Survey Vol. CCC, pp. 192, 194, 195; Vol. B pp. 40, 43.

Analyses of Pennsylvania chromite.

	1.	2.	3.	4.	5.	6.
Cr_2O_3	24.26	52.64	51.56	60.836	63.384	53.36
Fe^2O	14.54	16.00	35.14	----	----	26.64
Fe_2O_3	---	---	---	38.952	38.663	7.41
Al_2O_3	4.40	10.00	9.72	0.928	----	5.98
NiO	---	---	---	0.100	2.282	0.14
CoO	---	---	---	----	----	trace
MnO	---	---	---	----	----	0.39
MgO	26.07	13.22	---	----	----	6.53
CaO	0.45	0.36	---	----	----	---
SiO_2	24.20	5.60	2.90	0.619	----	---
Loss on ignition	7.44	1.90	---	----	----	---
	101.36	99.72	99.32	101.435	104.329	100.45

1. Bird's-eye ore from dump, Wood's Mine, Lancaster County. Sample collected by the writer. This ore could be concentrated.

2. Massive ore from dump, Wood's Mine, Sample collected by the writer.

3. Chester County ore.

4. Chester County ore.

5. Massive ore, Wood's Mine. Sp.gr. 4.568.

6. Chromite crystals, Hibbard's farm near Chrome Run, Delaware County. Sp.gr. 4.78.

Analyses 3-6 from Second Pennsylvania Geological Survey Vol. B, p. 43.

Present conditions in Pennsylvania. During the World War several old mines were unwatered, examined, and some ore was shipped. However, no new mines were developed to the point where operations could continue after the cessation of war-time stimulation. Since the armistice some small developments and some stock-selling have been reported, but production has not been attained.

Future prospects in Pennsylvania. Pennsylvania chromites are of excellent grade. The individual deposits are large. They are situated near points of consumption, and under such local conditions that economic mining should be practicable.

It is contrarily reported that the known deposits are worked out, and that there is "plenty" of ore left underground in the abandoned mines. Operations during the war period showed that at least some ore remained in the old mines and in the old dumps. It is probable that a small, carefully-designed, modern plant of semi-portable type could operate profitably under present market conditions.

Large future developments will take place with the discovery of new large ore bodies. During previous mining operations many of the valuable deposits were accidentally discovered by underground developments, thus proving beyond question that ore bodies exist close to the surface without showing any visible surface indications.

Chromite ore bodies are magnetic and affect magnetic instruments in much the same way that magnetite does, although with less intensity. Very careful measurements of the earth's local magnetism at numerous places throughout the serpentine area would indicate the presence, approximate shape, size, and depth of such ore bodies.

It is believed that many square miles in southeastern Pennsylvania afford particularly favorable geological conditions for the formation of deposits of magnetite, chromite, and other minerals which do not appear at the surface. A careful coordinated magnetic survey would indicate the location of those ore bodies near the surface which affect the local magnetism, besides furnishing magnetic data for use by local land surveyors. This Bureau has conceived the idea of making such a survey for the benefit of the State as a whole. The cooperation of the United States Coast and Geodetic Survey has been assured in such work.

The proposed investigation would bring results of great value to the State, to the industries, to the communities near which and to the owners of the land under which the deposits occur. However, work of this type must be deferred for the present because of lack of funds.

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